

5 **CLAIMS**

We claim:

1. A computerized method for dental imaging comprising:
receiving a plurality of two-dimensional images of a oral cavity; and
generating at least one three-dimensional image of the oral cavity from the
plurality of two-dimensional images.
2. The computerized method of claim 1, wherein the plurality of two-dimensional
images further comprises a plurality of two-dimensional optical images.
3. The computerized method of claim 1, further comprising:
constructing a physical cast of the oral cavity from the three-dimensional image.
4. The computerized method of claim 1, further comprising:
generating the plurality of two-dimensional images of the oral cavity from a
common reference point in three-dimensional space.
5. The computerized method of claim 1, wherein the generating further comprises:
generating shape-from-shading data from the plurality of two-dimensional images
using a shape-from-shading process, the shape-from-shading data
comprising a first plurality of three-dimensional points;
generating range data comprising a second plurality of three-dimensional points
from the plurality of two-dimensional images using a range-data process;
fusing the range data to the shape-from-shading data, yielding fused data
comprising a third plurality of three-dimensional points;
registering the fused data, yielding registered data comprising a fourth plurality of
three-dimensional points; and
triangulating the registered data, yielding the at least one three-dimensional image
of the oral cavity.

5 6. The computerized method of claim 5, wherein the generating shape-from-shading
data further comprises:

estimating the direction of the illuminant from the plurality of two-dimensional
images, in reference to camera intrinsic parameters; and
determining a solution to a brightness equation, yielding the shape-from-shading
data comprising a first plurality of three-dimensional points.

10 7. The computerized method of claim 5, wherein the fusing the range data to the
shape-from-shading data further comprises:

calculating the error difference in available depth measurements of the range data
and the shape-from-shading data;
approximating a surface the fits the error difference, yielding an approximated
surface; and
correcting the shape-from-shading data from the approximated surface, yielding
fused data comprising a third plurality of three-dimensional points;

15 8. A computer-readable medium having computer-executable instructions to cause a
computer to perform a method comprising:

receiving a plurality of two-dimensional optical images of an oral cavity; and
generating at least one three-dimensional image of the oral cavity from the
plurality of two-dimensional images.

20 9. The computerized method of claim 8, further comprising:
constructing a physical cast of the oral cavity from the three-dimensional image.

25 10. The computerized method of claim 8, further comprising:
generating the plurality of two-dimensional images of the oral cavity from a
common reference point in three-dimensional space.

30 11. The computerized method of claim 8, wherein the generating further comprises:

5 generating shape-from-shading data from the plurality of two-dimensional images
using a shape-from-shading process, the shape-from-shading data
comprising a first plurality of three-dimensional points;
generating range data comprising a second plurality of three-dimensional points
from the plurality of two-dimensional images using a range-data process;
fusing the range data to the shape-from-shading data, yielding fused data
comprising a third plurality of three-dimensional points;
registering the fused data, yielding registered data comprising a fourth plurality of
three-dimensional points; and
10 triangulating the registered data, yielding the at least one three-dimensional image
of the oral cavity.

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12. The computerized method of claim 11, wherein the generating shape-from-shading data further comprises:
estimating the direction of the illuminant from the plurality of two-dimensional images, in reference to camera intrinsic parameters; and
determining a solution to a brightness equation, yielding the shape-from-shading data comprising a first plurality of three-dimensional points.
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13. The computerized method of claim 11, wherein the fusing the range data to the shape-from-shading data further comprises:
calculating the error difference in available depth measurements of the range data and the shape-from-shading data;
approximating a surface the fits the error difference, yielding an approximated surface; and
30 correcting the shape-from-shading data from the approximated surface, yielding fused data comprising a third plurality of three-dimensional points;
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14. A three-dimensional digital image of a human oral cavity produced by the process comprising:

5 generating a plurality of two-dimensional optical images of the oral cavity from a common reference point in three-dimensional space;

generating shape-from-shading data from the plurality of two-dimensional images using a shape-from-shading process, the shape-from-shading data comprising a first plurality of three-dimensional points;

10 generating range data comprising a second plurality of three-dimensional points from the plurality of two-dimensional images using a range-data process; fusing the range data to the shape-from-shading data, yielding fused data comprising a third plurality of three-dimensional points;

15 registering the fused data, yielding registered data comprising a fourth plurality of three-dimensional points; and

triangulating the registered data, yielding the one three-dimensional image of the oral cavity.

15. The three-dimensional digital image of a human oral cavity of claim 14, produced by the process wherein generating shape-from-shading data further comprises:

20 estimating the direction of the illuminant from the plurality of two-dimensional images, in reference to camera intrinsic parameters.

25 16. A system for dental diagnosis comprising:
a processor; and
software means operative on the processor for generating a three-dimensional image of a human jaw, including generating shape-from-shading data that is generated from a direction of an illuminant of the jaw that is estimated in reference to camera intrinsic parameters.

30 17. A computerized system comprising:
a digitizer providing five degrees of freedom, having an arm;
a charge coupled device camera, rigidly mounted on the arm of the digitizer; and
a computer, operably coupled to the digitizer and the camera; receiving coordinate measurements from the digitizer and a plurality of two-dimensional

- 5 images from the camera; and generating a digital three-dimensional model from the coordinate measurements and from the plurality of two-dimensional images.
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18. The computerized system of claim 17, further comprising:
a rapid prototyping machine operably coupled to the computer, receiving the digital three-dimensional model and generating a physical model of the digital three-dimensional model.
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19. The computerized system of claim 17, further comprising:
a display operably coupled to the computer, receiving the digital three-dimensional model and generating an image of the digital three-dimensional model.
20. The computerized system of claim 17, the computer further comprises:
a computer readable medium comprising means of:
generating shape-from-shading data from the plurality of two-dimensional images using a shape-from-shading process, the shape-from-shading data comprising a first plurality of three-dimensional points;
generating range data comprising a second plurality of three-dimensional points from the plurality of two-dimensional images using a range-data process;
fusing the range data to the shape-from-shading data, yielding fused data comprising a third plurality of three-dimensional points;
registering the fused data, yielding registered data comprising a fourth plurality of three-dimensional points; and
triangulating the registered data, yielding the one three-dimensional image of the oral cavity.
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